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Addenda and Corrigenda to the following pamphlets :—

Pamphlet No. 1, 1915. Notes on the spraying of tea.

Page 42. Caustic Soda 2 lbs. should be added to the formula for soda copper emulsion.

Page 65. The weight of a ton in metric figures should read 1106·045 kilograms.

Page 66. The volume of one ounce in metric figures should read 28·3966 c. cms.

Alterations made by the printers in the paging of the pamphlet after the final proof had left our hands have rendered a portion of the index unreliable, and sometimes it is necessary to refer to the page following the one given in the index. There are other unimportant printers' errors to which it is unnecessary to refer.

Pamphlet No. 1, 1916. Tea Roots part I.

A note under the plate *Thyradaria tarda* Bancr. has been omitted. It should be pointed out that this disease is the *Diplodia* root disease referred to in the text.

THE APPLICATION OF GREEN MANURES.

All planters are firmly convinced of the value of green manuring, and the practice of treating annually a large part of the total area of a garden with a green crop is now very generally recognised as a valuable piece of garden routine, but it is possibly not always the case that this form of manuring is done in the best possible way.

In the cultivation of many crops other than tea it is customary to fertilize the field by means of a green manure, which is buried previous to the sowing of the crop, and this practice generally yields large increases ; but there have been many cases where such a practice has led to substantial decreases in crop compared to the crop from unmanured check plots. In the Final Report of the Heeleafa Experimental Station (1910 No. 4) cases of loss of crop from the use of green manures are recorded, and the harm done was ascribed to the drought which occurred in the first six months of that year. Since it is known that green manuring may result in harm under certain conditions, it is clearly essential to have some understanding of what those conditions are.

While the manner of action of green manures in improving crop is not yet thoroughly understood, and further work on the subject may lead to the recognition of new and important factors, yet a few principles have been established, and it is the object of this article to show how attention to these principles may tend to ensure maximum benefit from the application of green manures.

The Indian Tea Association published some years ago results of several experiments during which weekly pluckings from green manured and untreated check plots of tea were recorded.

The manures used were Mati-kalai and Dhaincha (*Phaseolus* sp. and *Sesbania aculeata*).*

* Mann and Hutchinson "Green manuring in tea culture in India" 1906; and Quarterly Journal 1913. (See plate facing p. 45.)

The production of leaf in each of the many experiments showed, by the end of the season, a considerable increase in favour of the green manured plots. On reference to these figures, however, it will be noticed that the green manured plots were behind the check plots during the earlier portions of the experiments (1) while the green manure was growing, and (2) for a period of about one month after burial. We will consider separately the reasons for the falling off in yield during each of these periods and briefly discuss methods by which these losses may be minimised.

In these experiments a fairly quick growing crop was sown thickly and hoed in as soon as sufficient growth was obtained.

While green manures are growing at least one round of light hoeing is missed. The value of surface cultivation is well established by agricultural experience, and the loss of a round of hoeing no doubt causes appreciable loss of crop in tea cultivation.

In addition it is well known that the effect of one plant growing in the neighbourhood of another is always harmful. The obvious explanation of this is the competition for water and food; and there appears to be a further reason for this effect. It was shown at the Woburn Experimental Fruit Farm, and again at Pusa that if grass is allowed to grow round apple trees the bad effect is considerable. In the course of researches on this point it was shown that the mere washings from grass and other plants growing in trays were distinctly poisonous to plant life.

Of the factors mentioned water is the most important. In many of the reported failures of green manuring the cause has been shown to be that the green manure had lowered the moisture content of the soil sufficiently to affect greatly the following crop. In the tea districts the soil generally has ample water during the rains for both tea and green manure plants, but the point should still be borne in mind and care taken not to leave a big crop standing during the cold weather, nor should a green crop be sown before the soil is thoroughly moist and likely to remain so.

Should a drought set in after the sowing of the green crop, it may be necessary to sacrifice the crop. In the event of serious drought not only should there be no green crop, but jungle should be carefully kept down.

Even with sufficient moisture the bad effect of a crop growing in the neighbourhood of the tea remains, and we must consider how this effect may be made as small as possible. The method which suggests itself is to make the period of growth as short as possible. It may be thought that the more rapidly the green crop grows the worse will be the effect on tea; but the growth of the green crop affects the other plants of its own species also, and if soil and other conditions are so good that fine rapid growth is made by the green plants in spite of competition among themselves, the health of the tea also must be affected favourably by these conditions and be better able to stand this competition.

It may be that by manuring, for example, the immediate benefit to the green crop is much more than to the tea, but in general the plants selected for green manures require much the same conditions for good growth as does tea, and the tea undoubtedly derives some immediate benefit from the manures, and it is certain that it is harmed much less by a quickly grown crop than by a crop of the same weight occupying the soil for a longer period.

Our problem then is to get a large weight of green matter in a short time, and this may be done by paying attention to five points :—

- (1) choice of plant.
- (2) choice of season for sowing.
- (3) preparation of the seed bed.
- (4) manuring.
- (5) choice of time for hoeing in the crop.

1. *Choice of plant.*—On this first point much work has been and is still being done by this Department, by the Agricultural Research Institute at Pusa, and by the Scientific Staffs attached to Provincial Governments.

Perhaps the best plants at present known for this purpose in the case of tea are Cowpeas (*Vigna catjang*) Sunn hemp (*Crotalaria juncea*) and Dhaincha. (*Sesbania aculeata*.) and, for the Darjeeling district Bhotmas or Soy Bean (*Glycine hispida*).

2. *Choice of season for sowing.*—A sufficient supply of water and a suitable temperature are of course necessary for rapid growth.

The conditions in these respects are generally satisfactory in the tea districts at the beginning of the rains.

Generally speaking April will be found the most satisfactory month for sowing green crops in Assam. In the Dooars and other districts where good early rains cannot be depended on, probably June would be found generally suitable.

Quicker growth will be obtained as the season warms up, but since early sowing will leave a longer part of the season during which the good effect of the manuring may operate, the exact date of sowing must depend on the judgment of the manager, and success will always depend to some extent on the luck of the weather, as it does in most agricultural operations. Late sowing will usually be found to interfere seriously with plucking because either the green crop or the plucking will have to be neglected and so it is advisable to sow as early as moisture conditions will allow.

3. *Preparation of the seed bed*—should need little comment.

The land, of course, should be clean to give the green crop a good start and so reduce the competition with jungle; and the surface should be as well pulverised as the coolies can be induced to make it. The seed should be lightly covered and with earth after sowing.

On one garden where good results are obtained the method is as follows:—On the day following a light hoe the surface soil is loosened by rapidly pulling a fork hoe over it. The seed is then broadcasted, and by pulling over it a rake of the right size to go between the bushes, most of it is then nicely covered.

Sometimes a harrow of jungle or bamboo branches is used. While soil must be moist, a time of excessive rain should be avoided, particularly on soils inclined to be heavy. Even the easily germinated seeds used for green manuring will rot if sown in land which is too wet.

4. *Manuring*.—It is not suggested that it would always pay to manure simply to obtain increased growth of green crops; but since all the manurial substances used by the green crop are returned

to the soil for the use of the tea when the green crop decomposes, care may be taken where possible to choose, as the sections on which green crops are to be sown, those on which it has been decided to apply artificial manures, and we are inclined to think that this combination of the use of artificial manures and green crops is the soundest method of manuring of tea.

It often happens, however, that just those soils which urgently require organic matter will not grow a green crop unassisted. In such cases the soil must be specially manured for the sake of the green crop.

The particular manures necessary will of course depend upon the soil, but attention may be drawn to one or two points of general application.

Treatment of the soil with lime and phosphatic manures will practically always assist the growth of leguminous plants, and potash very frequently does so. Light dressings of nitrogenous manures may be necessary to start growth; but part of the work expected of a green crop is to gather nitrogen from the air, and it will do this to a smaller extent if the soil is already well supplied with available nitrogen. Cattle manure even in light dressings often has a remarkable effect in promoting the growth of green crops when other manures fail, probably because it provides a favourable environment for the beneficent bacteria which are frequently lacking in the infertile soils under consideration.

Since a green crop will require to use them at once all manures for the purpose of assisting a green crop should be in readily available forms.

The cattle manure should be well rotted previously. Fresh organic manure hinders germination.

5. *Choice of time for hoeing in the crop.*—The time for hoeing will in general be when full growth is obtained and the seed just begins to set. It is then that the plant contains its highest percentages of plant food substances. Other considerations may modify this. The plant may be a climber and then must be hoed in before it makes itself a nuisance by climbing among the tea bushes. A thick top should not be on the ground too long for reasons already

explained. If sufficient growth is not obtained in ten weeks the crop may be considered a failure and had better be hoed in. Six weeks may be taken as the average time required to get a crop of about three tons per acre under fair conditions of soil and weather. This quantity will often be exceeded in a shorter time. The crop must be hoed in, as will be explained later, well before the soil may be expected to be dry.

The practice of leaving a crop to rot on the ground is much less good than that of hoeing the crop in. Such great loss of efficiency may result, from the former practice, that the sum total of all the effects coming into action may easily result in more harm than good.

The above remarks apply more particularly to crops such as Mati kalai, Cowpeas, etc., which are grown thickly and buried as soon as ready.

The slower growing plants like Boga medeloa (*Tephrosia candida*) and Rahar dal (*Cajanus indicus*) are useful in a different manner. These are tall crops giving a large weight of green matter for a comparatively small space of ground occupied. Such a crop will be grown in alternate lines between the tea, or in small clumps of two or three plants each at ten or more feet apart, so that its effect on the neighbouring tea is as little as possible, and it will not greatly interfere with cultivation. If these hedges or clumps are cut at intervals *immediately before a light hoe*, a large weight of green material is added to the soil during a season.

This is an excellent method of green manuring and often adapts itself to labour conditions more easily than the use of a quick growing crop which must be hoed in as soon as ready. It has additional advantages comparable with those obtained by the use of sau trees. Its light shade, and the action of its roots in breaking up the soil may be beneficial, although the roots may not be very deep. On inefficiently drained land it may even help the tea by assisting to dry out the soil. Apart from prunings useful manure is supplied by falling leaves and seeds. Plants used in this way have a very useful action as a wind break and much of the well-proved benefit, derived from such plants,—which

s probably best seen when they are grown in among young tea—must be ascribed to this reason. Hail storms, unless the wind happens to be along the lines of the hedges, must be much less damaging to tea thus protected. The disadvantage of this method is compared with that of using a quick growing crop is that a comparatively small quantity only is added to the soil at each cutting. A crop of Cowpeas not only improves the tilth and general health of the soil by the addition of organic matter, but is also equivalent to a good dressing of nitrogenous manure. With nitrogenous manures even more than with others, it is necessary that a certain concentration be reached before any effect is produced. The quantity of nitrogen added to the soil at one cutting of a crop such as Boga medeloa grown in the way described is probably not great enough to give the concentration necessary to have much effect from the point of view of nitrogenous manuring.

The temporary bad effect on the tea following the hoeing in of a green crop is usually very definite and is often obvious even to the eye. It has been observed by many planters that the growth of the tea is then checked and this is usually ascribed to the sudden removal of shade. This may be a contributing factor but it is not the main cause. In this connection an experiment carried out at Pusa,* may be quoted usefully because it illustrates very well the effect under consideration.

"Three plots were green-manured with Sunn hemp on July 15th, August 7th and August 28th respectively. On September 24th, a strip down the middle of these plots was subsoiled† to a depth of about twelve inches two days before the tobacco was transplanted. The arrangement of the plots is shown in the following diagram :—

Plot No. 1.	Plot No. 2.	Plot No. 3.
Green manured July 15th.	Shaded strip subsoiled September 24. Green manured August 7th.	Green manured August 28th.

* See Howard. Soil Ventilation—Bulletin 52—Agric. Res., Inst. Pusa.

† i.e. deeply cultivated.

"The results of the experiment were very striking. The tobacco in plot 1 grew very rapidly from the beginning and gave the best results. Plot 2 was not so good, while plot 3 was poor. In all the plots particularly in plots 2 and 3, subsoiling gave a marked increase in the appearance of the tobacco on this strip suggested a liberal dressing of nitrogenous manure."

The experiment shows that the green manure had a bad effect 29 days after burying, while its full benefit had not yet come into effect at 43 days, yet its good effect after 66 days was very marked. The effect of cultivation in hastening decomposition of the buried green manure was also shown. In tea cultivation therefore, a green manuring crop should be grown as early as weather conditions permit, so that the benefit resulting from the green manuring may have the greater part of the season in which to operate.

In 1912 Hutchinson and Milligan, at Pusa, commenced a series of experiments having for its object the determination of the factors influencing the results of green manuring. These experiments, as far as they had gone, form the subject of a pamphlet, "Green manuring experiments 1912-13" (Bulletin No. 40 Agric. Res. Inst. Pusa).

It is extensively quoted in the following pages, but planters would find the whole pamphlet of great interest.

The experiments showed that water supply is the limiting factor in the successful use of green manures from the point of view both of the water used by the green crop during growth, and of the proper decomposition of the buried plant in the soil. That the water supply is generally sufficient for green manures as generally applied to tea is the reason why complete failures have been so few.

Hutchinson's experiments in the laboratory determined the rate of decomposition of the Sunn hemp in samples of soil with varying moisture contents, both by measuring the rate at which carbon di-oxide was formed, and by measuring the rate of nitrate formation.

The main benefit of green manuring is no doubt derived from the organic matter provided, but the effect of a good crop as a nitrogenous fertilizer is considerable, and in any case the rate of nitrate formation is an index to the rate of change of undecomposed vegetable matter into useful humus.

Hutchinson shows that this rate of change is greatest in soil which is about two-thirds saturated with water and that the drier the soil the slower is the rate of formation of nitrates. In the case of Pusa soil about 18% was found to be the optimum water content.

In completely saturated (water-logged) soil no nitrates at all are formed.

The change appears to take place in two stages. During the first stage, which takes place most rapidly in the absence of air, certain substances are formed which are poisonous to plants. It is, no doubt the presence of such substances which is responsible for the bad effect on the tea following immediately on the burial of a green crop. At the second stage the presence of air is required, and this is necessary not only for the formation of the nitrates, which are the natural nitrogenous food of plants, but it also destroys the poisonous substances formed during the first stage of decomposition.

"Apart from the provision of an adequate water supply the complete break-down and subsequent nitrification of the green manure will depend upon proper aeration of the soil during this process, thus Sunn hemp buried in soil in which the water content was kept up to 20 per cent., but without stirring of the soil, failed to decompose after 12 weeks, whereas 16 per cent. of water was sufficient to produce complete disintegration when the soil was stirred up once a week."

"In the anaerobic decomposition of vegetable matter toxic substances are necessarily produced in the early stages, these would include many of the compounds found to be toxic to plants by Schreiner and Skinner and probably nitrites also. The effect of drainage in neutralizing such toxins has been shown by experiment (Agricultural Journal

of India, Vol. VIII, January, 1913) in rice cultivation and in fermenting green manure for subsequent application to the land account would have to be taken of the necessity for destroying such toxic bodies. One of us has seen several cases in tea cultivation where serious injury to the tea bushes, resulting in a large percentage of deaths, was effected by burying swamp soil, locally known as bheel soil, in pits between the bushes. Such material before burial should be exposed to aeration to insure oxidation of toxins and of ferrous salts generally present, and similar precautions would be necessary when using incompletely fermented green manure.

Where heavy rainfall or flooding has produced water-logging of a soil containing buried green manure, and drainage conditions are insufficient either to prevent such water-logging or to remove its effects with sufficient rapidity, an accumulation of toxins may take place sufficient to produce serious depreciation in the following crop. Harrison in a recent paper on soil conditions in rice cultivation suggests that the comparatively large supply of oxygen provided by the "surface film" is necessary for the healthy growth of the rice plant and it seems highly probable that one of its principal functions is to neutralize the toxins produced by the decomposition of the green manure buried in the saturated soil in which the rice is growing. That such toxins are produced and that they are removed in solution by water passing through the soil, was shown in the experiment carried out at Pusa on drainage of rice soil above cited, not only by their effect on the growth of the whole plant and on that of the roots especially but their presence was demonstrated by the toxic action of a water extract of the soil upon bacterial cultures. That such toxins are formed during the initial stages of decomposition of organic matter has been shown by an experiment carried out at Pusa this year (1913) in which green manure buried in wet rice produced decided toxic effects on rice seedlings when the latter were

transplanted whilst the decomposition of the green matter had only been going on for 24 hours ; after 14 days from burial of the green manure, seedlings transplanted into the green manured soil showed within 48 hours decided improvement in growth over controls in unmanured soil, and still more so as compared with those exposed to toxic action of the green manure during the earlier stages of decomposition."

Clearly, then, little benefit is to be expected from burying green manure in a soil that is either too dry or is water-logged.

In the tea districts the moisture in the soil is not often likely to be dangerously low if the manure is applied at the right season, but the second point should be carefully noted. Only harm may be expected from green manuring a water-logged soil. Insufficiently drained, heavy soils, which must frequently suffer from water-logging, are still too frequently found, and the drainage of such soils should be carefully attended to before green manuring is attempted.

From the above considerations Hutchinson & Milligan make an entirely novel suggestion.

"Sufficient evidence appears to exist to warrant the assumption that the successful use of green manure depends more upon the presence of the proper quantity of soil moisture to effect its decomposition than upon any other factor. It is worth while therefore, to consider the possibility of diminishing the degree of uncertainty necessarily resulting from dependence upon favourable weather conditions, and with this end in view we should wish to suggest the preliminary treatment of the green crop before burying in order to bring it into a condition in which some of the plant food it contains may exist in an available form, whilst the remainder, and probably the major portion, will have gone through the preliminary stages of decomposition and will be readily attacked by ammonifying and nitrifying organisms. Here we should have a close analogy with the rotting of farmyard manure

and probably an imitation of the method of making *seet*, but in view of the fact that the latter is produced merely incidentally as a by-product, in indigo manufacture, it is probable that modifications of the method may be found, resulting in a better manurial material.

"Assuming the feasibility of such a method a further advantage beyond that of proper decomposition would lie in the control of the rate of such change and the application of the resulting manure to the land at the proper moment."

"A further advantage of the suggested method would be the fact that the green manure crop could be grown in many cases on areas unsuitable for the crop intended to benefit by its use, and that by this method depletion of the soil moisture by transpiration from the green manure crop would not effect the rabi crop to which the green manure was applied.

"One of the most important points in connection with the use of manures, and especially nitrogenous ones, is the necessity for ascertaining the optimum rate per acre at which they may be applied. In the case of nitrogen it seems clear that until a certain concentration of this element in the available condition is reached in the soil, no beneficial manurial effect will be attained. In the case of green manures failure to produce positive results may in many cases be attributed to this cause, as the actual amount of nitrogen becoming available as plant food through decomposition of the buried crop may be so low on account of the small amount of it actually contained in the crop and coming slowly into operation, the necessary concentration is not attained. It is further suggested therefore that the rotted material obtained in the manner above described should be applied not to the whole area upon which it was grown, but upon such a fraction of it as experiment may show to give the best return. This point will form a subject for experiment in the current and following seasons.

"The general method suggested, therefore, is that the green manure crop should be cut, steeped in water and allowed to ferment in heaps, after which it should be put upon the land."

"The best method of doing this and the relative cost and value as compared with the ordinary practice will form a subject of enquiry during the present and following seasons."

We do not think that on the present evidence the suggestion should be followed out in the case of tea except on a small scale for experiment. The conditions for green manuring in tea as at present carried out are exceptionally favourable, particularly with regard to water content of the soil, and the operations of cutting, carting away, steeping in water, placing in heaps to ferment, exposing to aeration, and then carting back to the soil would probably be too costly to be profitable. However the suggestion is exceedingly interesting and the results of further experiments will be awaited with interest. The suggestion of thus utilizing waste land is one that may prove of practical value in tea cultivation, and the treatment suggested might also be applied at small cost to the jungle that is sometimes cut for the purpose of applying to the soil as manure, e.g., to the jungle which grows in "hullahs" or "jhoras." On many gardens tracts of waste land growing plants very suitable for this purpose may be noticed. Any green succulent plant such as elephant grass, tarapat, (*Alpinia sp.*) or plantain would make excellent manure if treated in this way.

Whether nitrogen is added to the soil in sufficient concentration by burying a green crop in the area upon which it grew, will depend upon the size of the crop obtained.

An average of ten experiments made in this laboratory showed that cowpeas immediately after cutting contain 0·4 per cent. of nitrogen. A crop of three tons therefore contains nearly 30 lbs. of nitrogen or as much as is contained in about seven cwt. of oilcake. Probably a higher percentage of the nitrogen of oilcake becomes available for plant-food than is the case with cowpeas, but if we make an exceedingly liberal allowance for this, it is still

clear that if a good crop is obtained green manuring as usually applied must be effective as a nitrogenous fertilizer for tea.

From the above the main principles of effective green manuring in tea cultivation may be summed up by saying *Grow a heavy green crop as quickly as possible, while the soil is moist, and hoe in the crop when the soil is wet (but not water-logged) and likely to remain in that condition for one or two months.*

A few subsidiary points which are yet of great interest and importance remain to be dealt with.

Depth of burial.

The optimum depth of burial was found to vary with the age of the plant and with the character of the soil. In the case of Sunn hemp on the Pusa soil it was found that after six weeks' growth the best results were obtained by burying three inches deep, while with ten weeks' old plants those buried at nine inches deep did better than those buried at more shallow depths, but the results with the older crop were not so good as those obtained from the younger. Deeper burial, also, is advised where the soil is somewhat dry.

These results agree with those already quoted with reference to the necessity for air and water. Water content of the soil is the chief factor affecting decomposition of green manure, but if the soil is moist near the surface, it is better to bury green manures near the surface where the necessary air is more readily available. When the soil is drier, a sufficient air supply is found at a greater depth, and the soil being moister at the greater depth, better conditions are then obtained by deep burial. In light soils, where more air and less water will be found than at a corresponding depth in a heavier soil, burial should clearly be deeper than in heavy soils.

The practice of burying green manure in trenches when the soil is dry is, in view of the researches above described, now seen to be sound.

Effect of age of plant and of moisture content of green-crop at the time of burial.

"The successful decomposition of the buried green crop has been shown to be determined largely by the presence of

an adequate supply of water for the needs of the saprophytic organisms upon which this process depends. It is therefore to be expected that the moisture content of the green plant at the time of burial will materially affect the result, as also will the condition of the tissues in this respect. Thus the decomposition of the younger plants is as much more rapid than that of the mature ones as the water content of the former is higher than that of the latter, and those parts of the plant containing the highest proportion of cell-sap have been found to decompose more readily than the maturer portions.¹³

This point is illustrated by a table showing the relative rates of nitrate formation from Sunn hemp at 4, 6, and 10 weeks old.

A further table compares the results of burying freshly cut Sunn hemp and Sunn hemp that had been allowed to dry for various periods. It is shown that the best results are obtained by burying immediately and that the loss by allowing to dry after cutting increases with the length of time elapsing before burial.

Both these points are very important. The first sets a limit to the time during which a green plant can be usefully left growing. When woody tissue begins to be formed at the expense of succulent green growth, only loss of efficiency will result from an attempt to get a larger weight of green crop before hoeing in. It follows, too, that those plants which give much wood are less desirable for green manuring than those which are mainly or altogether composed of succulent green tissue. From this point of view a crop like Cowpeas (*Vigna catjang*) is to be preferred to one with a woody tendency like Dhaincha (*Sesbania aculeata*) but taken at the right age Dhaincha will give a fine weight of succulent green matter, and since it does not climb among the bushes it is probably the better crop of the two on areas where the bushes are very high and wide, or where the bushes are very close planted.

The usual practice is to bury a green crop without previous cutting and this can now be seen to be a very sound method. In cases where a green manure is cut or pulled up before burying,—for example when it is required for trenching,—care should be taken to

bury it as soon as possible. The same principle applies to prunings ; whether they are to be buried with a deep hoe or in trenches they should be got into the soil as soon as possible after cutting from the bush.

Effect of cultivation.

The experiment already quoted shows the advantage of stirring up the mixture of soil and green manure during the decomposition of the latter. This is in agreement with the effect of sub-soiling quoted in Howard's experiment. It was again confirmed by Hutchinson and Milligan that the conditions are improved by allowing access of air to the decomposing vegetable matter, in an experiment where it was shown that decomposition went on much slower in rolled than in unrolled soil.

It is clear, therefore, that cultivation must not be neglected after hoeing in a green crop. Indeed, it would be of great advantage if labour would allow of extra cultivation at that time. A round of light hoeing a fortnight after burial, and a second hoe after another two weeks' interval would very greatly increase the efficiency of the green manuring.

The same principle applies to all organic manures, but is of chief importance in the case of a bulky green crop.

Effect of phosphatic manures.

Hutchinson shows that the rate of decomposition of green manure in the soil is greatly increased by the presence of phosphatic manures.

Meggitt (Agricultural chemist to the Government of Assam) had previously shown that the use of a green crop in conjunction with bone meal increases the availability of the phosphoric acid of the bone meal.

In Part IV 1915 of this Journal some experiments are described showing the remarkable effect of phosphatic manures on the rate of growth of green crops.

So great is the effect of these three factors—increase in quantity of green manure as the result of phosphates manuring and great increase in efficiency of both green and phosphatic manures when

In conjunction—likely to be, that the combination of phosphatic with green-manuring is strongly recommended. In fact it would be a good rule always to precede the sowing of a green crop with say two cwt. of basic slag or superphosphate. By doing so a much better green crop will be obtained, and also both the green manure and the phosphate will be more effective as manures for the tea than if used alone. Where the sum which it has been decided to spend on manures will not allow special treatment of the areas to be green cropped, the sections selected for green cropping should be those which have received phosphates either in the same or the previous year.

TERMITES IN THE LUSKERPORE VALLEY

BY

E. A. ANDREWS, B.A.

During January 1916 the writer visited the Luskerpore Valley of South Sylhet, and while there was able to make observations on the subject of Termites and their depredations in that district which, it is believed, mark a distinct advance in our knowledge and understanding of these pests in tea. The following article gives a short account of these observations, and will, it is hoped, be of material assistance to those whose estates are subject to damage by this form of termite. Where other forms of termite (for that there are other forms in other districts is certain) are responsible for damage to the bushes, the following remarks will not of course apply *in toto*, but our present knowledge of the habits of other forms leads us to the belief that the suggestions made on pruning, if properly carried out, cannot but be of assistance in dealing with those forms also.

A general account of Termites and their economy has been given in a previous number of this Journal,* and we shall here confine ourselves to a particular description of the Luskerpore forms, of which there are two,† one of which builds a mound, while the nest of the other is entirely below ground-level. These two forms, apart from the external appearance of the nest, are similar. Soldiers and workers of both forms are identical in appearance, and the nest, in each case, is built up on a similar plan. In both forms there are large and small workers and soldiers, with young individuals of each form, and nymphs.

* "On Insects. Part III"—pp. 3 to 8 of Part I, 1915.

† In one instance a third form was found, the nest of which was constructed inside the stem of a seed-bush. The investigation of this uncommon form, which was not found in the plucking area, is a matter for subsequent inquiry.



A.

B.

Plate I.

Microphtographs of heads of Termites, showing the form
of the jaws:

A. - Large soldier.

B. - Large worker.

The individuals to be found on the bushes are the workers and soldiers.

The large worker, when alive, is an eighth of an inch in length, about three times as long as broad, active, with a large yellow-brown head, carried at right angles to the body. The head measures one-tenth of an inch from the crown to the tip of the jaws or mandibles, and is slightly less in breadth. The jaws are square-ended, with a black, hard, serrated edge, and are very large and powerful. Within these is a pair of smaller pointed jaws, and each pair of jaws is provided with small palp or feeler. There are no eyes, but on the head is a pair of mobile feelers, or antennae. The thorax, to which the six legs are attached is visible as a somewhat constricted portion of the body immediately behind the head. It swells out behind into the abdomen, which is usually of a dull yellow colour, but varies considerably, and may or may not appear to be marked with black or brown, according to the contents of the gut (Plate I., A.)

The large soldier is slightly larger than its corresponding worker, and is a little over a fifth of an inch in length. The yellow-brown head, also, is larger, and measures an eighth of an inch from the crown to the tip of the large jaws, which are pointed, and drawn out almost like a pair of calipers, the remainder of the mouthparts being reduced. The head, in the soldier, is not carried at right angles to the body, but at an angle of about forty-five degrees, and when danger threatens is lifted to an almost horizontal position, with the jaws extended forward in a threatening manner. It also has two pairs of palpi (or mouths feelers) as in the worker, is without eyes, and carries a pair of mobile feelers or antennae. The thorax, as in the worker, is somewhat constricted, swelling out into the abdomen behind, and the hind part of the body is usually milky, sometimes yellowish. (Plate I., B.)

The small workers and soldiers appear to the naked eye as miniature editions of the large varieties, and are about a twelfth of an inch and a tenth of an inch in length respectively. They are easily distinguishable from one another by the form of the jaws.

The nest of the mound-building variety takes the form of a roughly conical mound varying in size and shape according to the age of the nest and the conformation of the ground, and may attain a height of six feet or more and a diameter of fifteen feet. The older the nest, the greater the diameter compared with the height. The external surface of the mound is hard and compact, so much so as to be impervious, or practically so, to water, and the material of the mound throughout is similar, and appears to consist mostly of the finer particles of the soil from below.* In the centre of this mound, at or just above ground level, is the main chamber, about eighteen inches long by one foot high by eighteen inches broad (in the case of a mound three feet high). The floor of this chamber is raised in the centre, and the chamber is almost filled with a large "comb," a moist spongy structure built up of small pellets largely composed of organic matter cemented together. Minute globules of a white fungus are to be seen on the surface of the comb, and the cavities swarm with termites in all stages. In this comb, also, are clusters of the small, translucent, spherical eggs. Beneath the centre of the floor of this main chamber is a lenticular earthen cell, two, to two and a half, inches long by one inch broad by three-quarters of an inch high, which is the so-called "royal cell," and contains the king and queen of the colony. This cell communicates by passages with the main chamber, and owing to the elevation of the floor of this latter is encircled by it. From the floor of the main chamber a gallery of about an inch in diameter runs, at an average depth of nine inches to a foot below the surface of the ground, to a considerable distance from the nest, and opens to the surface by a network of small passages. The gallery may branch on the way or there may be

* The following mechanical analyses of soil from a termite mound, and of the neighbouring soil and subsoil, show the increased proportion of the finer particles in the soil of the first.

		<i>Mound.</i>	<i>Surface Soil.</i>	<i>Subsoil.</i>
Coarse sand	...	... 5.80%	12.29%	10.10%
Fine sand	...	... 51.07%	60.60%	60.35%
Silt	...	... 10.39%	7.74%	6.86%
Fine silt	...	... 11.09%	7.43%	8.55%
Clay	...	... 11.17%	4.02%	6.18%

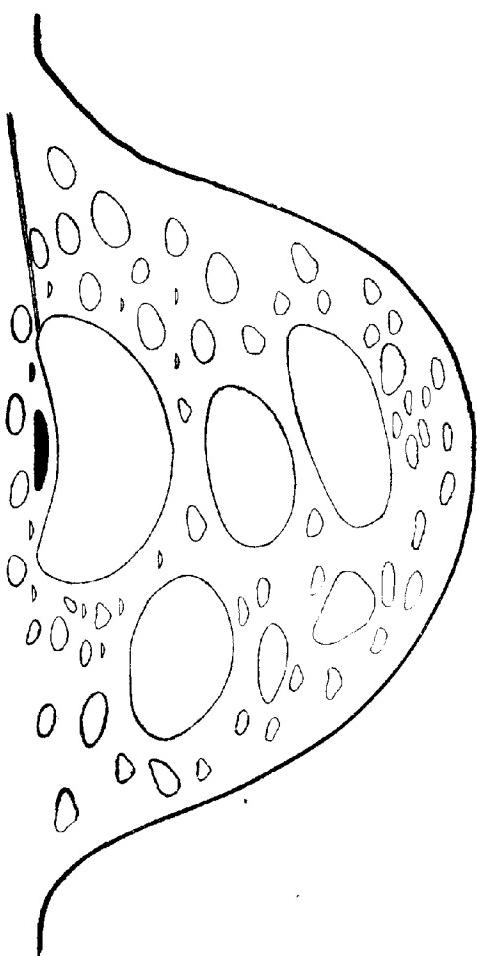


Plate II.

Diagrammatic vertical section of the nest of the mound-building form. The royal cell (black), the large and small comb-cells, and the peculiar nursery cells can be seen.

more than one gallery, but each gallery ends in a ramification of small passages before reaching the surface of the ground. Further, the gallery opens into the main chamber by a series of small passages and communication with any chamber which it may pass is similarly established by small passages.

Immediately around the main chamber are small smooth-walled lenticular cells an inch to an inch and a half in diameter containing clusters of eggs and young, all attended by workers. These small cells contain no comb, and the young termites appear to be removed from the egg-cells almost immediately after hatching, and transferred to another cell, where they are attended to by workers until sufficiently developed to enter the main nest. A little further from the main chamber are similar lenticular cells containing nymphs, attended by workers. In many of the chambers were small pieces of comb, from which a good deal of fungus had been removed, which appeared to have been brought into the chamber to supply food for the young forms. The small and young workers appeared to be entrusted with the task of nursing the young. Interspersed irregularly with the lenticular cells are irregular comb-cells of from three to five inches in diameter. These cells contain small combs, and are occupied by young termites and small soldiers and workers.

Above the main chamber are more large comb-chambers, their number varying with the age and size of the nest. They contain large combs, like the main chamber, and likewise swarm with large numbers of all castes of the colony, but never seem to contain eggs. Around and among these chambers are small chambers, some containing comb, others being empty, and in at least half of the nests opened the uppermost large chamber contained no comb. The large chambers never approach very closely to the external surface of the mound, but are always surrounded by a kind of screen of small cells. The whole nest appears to be built up on a rough ascending spiral, in a counter-clockwise direction (when viewed from above). The diagram, Plate II, shows a generalised vertical section through the centre of a typical mound.

In the case of the second form of the termite, which is the form responsible for the damage done to the plucking tea, only incomplete nests could be found, situated below the surface of the ground. In some instances the nest consists only of a few scattered comb-cells of the small type, together with a certain number of the small, smooth-walled lenticular cells connected by fine passages ; in other cases a large comb-cell is to be found, often situated, at a depth of a foot to eighteen inches, beneath the collar of a bush, surrounded by small comb-cells and smooth-walled lenticular cells, all connected by fine passages. When only small comb-cells are to be found, only the small worker and soldier castes, and their young stages occur, although nymphs may be found in the lenticular cells. When a large comb is present also, both large and small workers and soldiers, and their young stages, occur, together with nymphs. No queen was found in any of these incomplete nests, nor were eggs found to occur in them. Passages lead away from these nests in all directions through the soil, many of them leading downwards, but they could not be traced to any large main nest either by digging or by means of a fumigating machine. It is probable, however, that there is some main nest deep down in the ground, else whence come the young workers and nymphs which are always to be found ? Lefroy, in " Indian Insect Life," says :—

" The termite of the plains of India is *Termes obesus* Ramb., specimens having been obtained from widely scattered places in India. This species nests either deep in the ground, or near the surface, depending probably upon the nature of the soil but this is not certain. Nests have been found and examined, as also have the small outlying fungus chambers that they make. In some parts of India the nests begin near the surface of the soil and stretch upwards in the form of conical mounds ; in other places they are at the surface but not above it ; elsewhere they are deep in the soil. This termite never shows above ground unless in a tunnel or gallery : the insects are seen only when they emerge in the winged state ; their tunnels were found in Pusa 11 feet below the soil level.

and were occupied by workers. Where they tunnel so deeply nests are never found ; small fungus chambers have been found but no nests ; and though the insects appear for instance in every part of the Pusa estate (1,300 acres), no nest can be found ; excavations made at the spot where the winged forms emerged in a great swarm revealed nothing."

The behaviour of the termites which attack the bushes in the plucking areas of the Luskerpore Valley appears to be similar.

While excavating round the roots of a bush attacked by small workers a pair of adult individuals, survivors of a recent swarm, were found in an earthen cell, at a depth of four inches or so, close the stem of the bush. Both individuals were of normal size, and had shed their wings. No connection could be traced between these "royal" individuals and the comb-cells or galleries of the other termites, and in no other instance were other royal pairs found. When a swarm of winged individuals takes place, many other similar cases must occur. What happens to these individuals ? Are they eventually found and destroyed by the workers, or adopted and taken below, or do they endeavour to begin a colony of mound-builders, and, being frustrated by continual cultivation, eventually die ? In the account of the nest of the mound-building variety, mention was made of the fact that the large comb-chambers never approach very closely to the surface of the mound, the peripheral portion of the nest consisting of small chambers. In the case of this form, also, a similar disposition of the chambers is found to obtain. Small chambers may be found when no large chamber is present, but a large comb-cell is never found without an encircling series of small comb-cells inhabited only by small workers and soldiers, and connected with the main cell by passages large enough to admit only the individuals of the small castes. This arrangement of the cells appears to be a defensive measure designed to protect the nest from the attacks of the black ant, *Componotus compressus* Fabr., whose nests occur in the surrounding soil. This marauder can pass through the galleries which

admit of the passage of the large workers, but cannot pass through the galleries of the small workers, and the outer network of finer passages effectually bars the entrance of this enemy.

In the foregoing remarks reference has been made to the large and small comb-cells. Two types of comb are constructed by this termite, which differ only in size, and not in material or design, the larger type being found in the main chambers, the smaller type in the auxiliary chambers. The comb has the form of a fragile spongy mass, convex on the upper surface and concave below, and is composed of small grains or pellets cemented together. These pellets are composed of organic matter, with a certain amount of earthy material. The organic matter is obtained from the plants attacked, the material removed from which is brought to the comb-chambers by the foraging workers, and is there chewed up to make the small pellets used in making the comb. That this is so is shown by the fact that occasionally, in new comb-cells, small orderly piles were found, consisting mostly of pieces of bark, with a certain amount of dry grass and other organic matter, which were just as they had been cut from the plants. The following chemical analysis of a comb from a termite mound shows the high percentage of organic matter contained therein :—

Organic matter ...	...	... 75.78% }
Silica ...	...	... 19.09% }
Potash ...	...	... 0.12% }
Phosphoric acid ...	...	... 0.35% } on dry substance.
Lime ...	...	... 1.45% }
Magnesia ...	...	... 0.60% }
Nitrogen ...	...	... 1.98% }
Water ...	...	... 11.9%

— The small type of comb is constructed entirely by the small workers while both large and small workers appear to co-operate

in the construction of the large combs. Also, the young individuals found on the small combs are the immature forms of the small caste of worker and soldier only, while young stages of both forms may be found on the large combs.

On this comb the termites cultivate a fungus, which takes the form of a milky film, with small white globules projecting from it. There are also, in some cases, fine threadlike filaments projecting outwards from the comb and inwards from the walls of the comb-cell. This fungus growth can often be seen to have been eaten off in places. Old abandoned combs become dry and hard, and lighter in colour, while retaining, to a certain extent, their spongy texture.

The method adopted by these termites in building is interesting, and worthy of description. If a breach be made in a nest various galleries will be exposed. Narrow galleries, which admit only the small workers, are not attended to immediately, but are left until the larger galleries have been closed. While this is being done a number of soldiers range themselves at the breach, head outwards, and remain perfectly motionless with the exception of their antennae, which are waved continually to and fro. In the meantime several workers begin to build a wall across the breach. Each brings along, from the interior of the nest, a small earthen ball, which she places in position after feeling for the place with her antennae. She then proceeds to mould it with her jaws, moving her head from side to side round the periphery of the ball, with the axis of the head always in line with a radius of the ball. After this she appears to test it with her antennae, and if dissatisfied, repeats the process, but if satisfied she hurries back into the nest, to return with another earthen pellet which is placed in position in a similar manner. The wall is built up in this manner from the bottom until only a small hole is left, when one of the workers is pushed through the hole to the outside by the others. She appears to go very unwillingly, but, once outside, immediately sets to work to assist in closing the hole, biting pieces of earth from the side and placing them in position in the

manner described above, while the workers inside place other earthen pellets in position. When the breach is entirely closed she carefully tests the whole of the wall with her antennae, placing extra pieces of earth here and there, and finally, when satisfied that all is sound, leaves the place, probably to perish elsewhere, unless she can find another way into the nest. The chief duty of the soldiers, whilst the repairs are going on, appears to be to give warning of the approach of a newcomer, for if the end of a straw or some similar object be dangled immediately in front of them, they do not attack it, as they would in the ordinary way, but, after touching the antennae of the neighbouring workers with their own, hurry away into the nest, while the workers, after a little aimless running hither and thither, continue to repair the breach. When all is quiet again the soldiers return, and take up their stand as before. Some idea of the rate at which these insects can build may be gained from the observation that the mouth of a large gallery almost half an inch in diameter was completely closed within five minutes, and so well was it done that on taking one's eyes from the place, it was exceedingly difficult to find again.

As stated above, the form of termite which is almost entirely responsible for the damage to the tea-bushes is that in which the main nest is probably situated a considerable depth below ground, only auxiliary comb-cells being found near the surface of the soil. These termites invariably attack the bushes above ground and as they never expose themselves to the light, and always construct an earthen gallery wherever they go, their presence on the bush is easily detected. They attack dead wood for preference and in the majority of instances their runs can be traced to snag, either produced through the accidental death of a branch by injury, or left in pruning. From such points of attack they will work both upwards and downwards, sometimes on the outside of the branch, sometimes inside, and sometimes inside and outside at the same time. In the absence of snags they will attack the older hide-bound parts of the bushes, and from there, having obtained a foothold, the younger growth from them. Young growth from wood in which termites have become established is

naturally liable to attack, as the insects are in a position to cut off supplies at the base. Occasionally the termites will go up young healthy growing branches, but rarely do material damage in the absence of snags or other injury.

One feature of termite attack is that it rarely extends below the collar,* and its presence there can usually be traced to some accidental contributory cause, such as the exposure of the torn end of a damaged root, a blow with a hoe, or through entrance to the roots having been obtained at some branch arising from a root. Time and again bushes which appeared to have been killed out by termites were found to be sound at the collar, and in less serious cases new shoots, untouched by the insects, had been thrown out from the collar. In cases where the tea has never been collar-pruned, the damage done is greatest. Having made an entry into the bush, they settle in the boss of wood so characteristic of "single-stem" bushes. Once there, they can only be eradicated by cutting below the damaged part, and as all the branches forming the bush arise from the top of the boss this would mean the removal of the whole bush. The termites are therefore allowed to remain, and eat away the heart of the boss, leaving an empty shell. While this is going on branches from the crown of the bush continue to grow and to flush, but they gradually become less and less productive, until eventually a time arrives when the whole of their supply of sap is cut off, and they begin to die back. While certain of the termites are hollowing out the single stem, others are attacking the moribund branches. When the bush has practically ceased to grow, it is found, in most instances, that new shoots are thrown out from the collar, which, if the boss were cut away, would form a new bush, but never get a chance so

* Since writing the above a communication has been received from the Juri Valley of Sylhet, in which it is stated that on the high lands of that district, during the cold weather drought, white ants had attacked and eaten the roots of the bushes some distance below the surface of the ground. Not having yet seen specimens, either of the bushes or the white ants, the writer is unable, at present, to offer any explanation of this. In the Luskerpore Valley no such case was found to occur, and the roots of the bushes were found to be uninjured even when the whole of the bush above the collar was, to all appearance, dead.

long as the old bush remains. Figure 1 illustrates, in a diagrammatic way, this state of affairs.

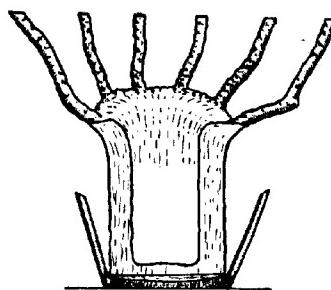


Fig. 1.

Single stem bush, in part section, showing the centre of the stem, above the collar, eaten away by termites, and new shoots arising from the collar.

In other cases, where branches have died back and are being eaten, while the stem of the bush is still sound, a similar attempt to carry on its existence is made by the bush, but under these circumstances the new shoots may arise, not from the collar, but from below the point of attachment of the damaged branch, to be again handicapped by the presence of the old moribund branch, as well as by the established position of the termites thereon, which gradually encroach, through the old hide-bound wood, to the base of the new branch, thus sapping its vitality.

Having now given some account of the general nature of termite attack on the bush, we will proceed to describe in more detail the character of the attack on different parts of the bush. Towards the end of the rains the termites begin to travel up the young branches, putting earthen runways on the branches as they go, and eating away the bark beneath these runs. The result is that when the earth is removed from slightly attacked branches the bark is seen to have been removed along certain lines, between each of which a narrow strip of bark has been left. This strip

of bark shows where the side-wall of the tunnel was attached to the branch. Figure 2 illustrates this:—

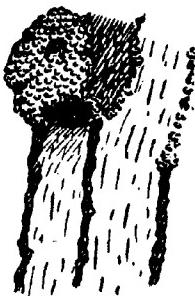


Fig. 2.

Showing the strips of ~~bark~~^{bark} left on the stem where the side-walls of the gallery are attached to the stem. Most of the earth has been broken off, but the end of one gallery, and the remains of the foundations of a second, can be seen.

Very often the bark is eaten away at the base of a side shoot, and eventually the base of the side shoot may be completely ringed, as shown in figure 3, so that the shoot is killed off, and the white ants effect an entrance to the branch at the resulting scar:—

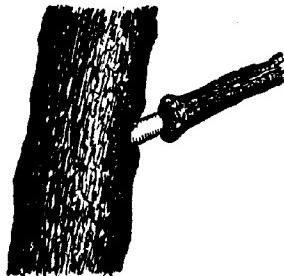


Fig. 3.

Side shoot ringed at the base by termites.

From this place they may either bore into the heartwood of the branch, or work up and down in the outer portion, eating away the branch so as to make it appear as if it had been cut with a gouge for a short distance. Eventually, if the insects are left undisturbed the earth runs will completely encircle the branch, and

the latter will be eaten away. This result was only found to occur in shoots growing from unhealthy wood in which the termites were already established. On really healthy branches growing from sound productive wood the insects do not seem to obtain a real foothold, and the damage done is comparatively slight. In all cases where apparently strong shoots, coming from the collar, had been attacked, they were seen to have suffered damage, e.g., from a hoe or a kurpy, and instances were not uncommon where, of two similar shoots from the collar, one was attacked and one left alone, the former being always found to have been otherwise damaged in some way.

In older wood the termites enter at snags or scars, and work up and down the centre of the branch, as shown in figure 4 :—



Fig. 4.

Section of a branch which has been attacked by termites which have entered at the scars left by dead branches.

In a thick branch the inner surface of the boring is lined with wet soil, and strengthened by pillars of soil at intervals, as shown in figure 5 :—

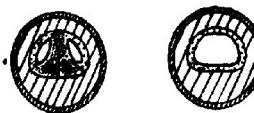
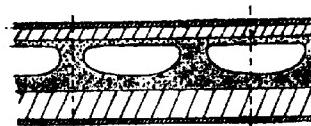


Fig. 5.

Longitudinal and transverse diagrammatic sections of a branch attacked by termites, showing the supporting pillars.

In many instances the insects had entered at a snag and working downwards inside the branch, had introduced a large amount of soil at a point near the base of the branch, and this, soil having been pressed in hard, the branch was bursting at this point. Work on the outside of the older branches is carried on the same lines as on the younger ones, but is usually more intense.

In all instances of white ant damage to the bushes the attack is commenced by the small workers, the large workers only attacking the bushes after the small ones have become fairly well established, and so long as the damage can be restricted to that done by the small workers it is not, as a rule, very serious. The presence of the large workers, even when they are not seen, can be detected by the strongly pronounced honey-comb appearance of the eaten surfaces of the old wood. When working in the bushes, as in building in the ground, the small workers always lead the way, probably with the object of ensuring protection against the attacks of their arch enemy, the large black ant. As an attack on the wood of bushes by the small workers, if they be left undisturbed, is a preliminary to attack by the large workers, it is well worth while to disturb the white ants continually in order to confine the damage to that done by the small workers.

Termites, besides damaging the bushes directly as described above, give rise to a great deal of damage which would not otherwise occur. Various species of ants nest in their abandoned runs and in the branches bored by them. The moist earth which they carry into the bushes has a deleterious action on them, the adjoining wood being found to be discoloured and dying to some distance, and water, lodging in their excavations, rots the wood of the bushes. Branches which are hollow, or partly eaten through, are very liable to break off when struck by the hoe.

In addition to attacking the old bushes, the termites will also attack young tea, and this was found to be going on in certain cases. The insects work, on the young plants, in a manner very similar to that in which they work on the young wood of the old plants (see above). Sometimes they effect an entrance at a scar where a twig has dropped off, or by girdling the base of a twig

as described above, and killing it off, while at other times they girdle the base of the main stem. They often enter the plant at several points. In either case the result is similar. When the base of the main stem is girdled and eaten into, the plant breaks off and falls over, and when the insects enter at a scar they eat away the wood, leaving only a ring of bark, at the point of entry, and the upper part not only dies back, but eventually breaks off at the point of attack. Cases of attack on young plants could usually be traced to weakness, due to bad planting, kinks in the stem, etc.

The observations made on the habits of the termites infesting the plucking tea in the Luskerpore Valley show that any step taken to mitigate the damage done must consist of methods calculated to keep the insects out of the bushes rather than attempt to kill the termites by direct means. The fact that the main nest cannot be located, and is presumably some distance away from the point of attack, renders any attempts at eradication, at the present time, abortive, and much better results can be obtained by taking advantage of their habits to reduce the damage done in the bushes. Once a mound has been levelled, the nest or the greater part of it has been destroyed, and continual cultivation will prevent its reformation. In the case of the other, and more serious, variety of the termite, however, cultivation does not destroy the nest. The utmost that can be expected is that the parts of the auxiliary nests which are not situated among the roots beneath the collars of the bushes, will be destroyed. Since cultivation, therefore, though it will check the activities of the insects to some extent, will not keep them out of the bushes, and since no other practical method of doing this has yet been devised, some scheme must be adopted which will tend to reduce the amount of damage that the insects can do when they get into the bushes. Such a scheme is to be found, not merely in careful pruning, which of course is a necessity, but in the adoption of a definite system of pruning based on a knowledge of the *modus operandi* of the termites in the bushes. That such methods are of appreciable and immediate value has already been demonstrated in the district, and the system outlined below, in instances in which it has been tried in part has been markedly successful.

The practice of cutting back to ten or twelve inches, which formerly obtained in this district, has resulted in the production of a large proportion of bushes with a high single stem, and as this has thickened out it has formed a great boss of wood, in which the termites, having effected an entrance, have been able to establish themselves. The formation of this boss of wood can be avoided, if the bushes, when cut down, are properly collar-pruned, care being taken to cut as low as possible. This leaves little or no useless wood above the collar to shelter the termites, and good strong straight stems can be obtained from the ground, which will, if carefully pruned resist attack for some time. Collar-pruning, with this object, was carried out on one garden in the district some six years ago, and although the bushes were riddled with termites before, the damage done since is practically nil. On all gardens of the district high-stemmed bushes which are riddled by termites attempt to come away from the bottom of their own accord, so there seems to be no reason why they should not do so if properly and intelligently collared. If collar-pruning be deemed too hazardous an experiment, the high-stemmed bushes might be notched, and cut down after they have made growth from below.

In course of time the stems of even a well-collared bush may be expected to become hide-bound, when the termites will probably attack them. When this occurs the style of pruning adopted should be designed to replace the white-ant eaten branches by young growing branches: In cases where the majority of branches have been badly attacked this scheme of replacement may extend over two or three years, a certain number of the more badly attacked shoots being removed at each pruning to make way for new ones. By this means new and healthy bushes can be built up in a few years, with little or no loss of crop in the meantime.

Pruning carried out on such lines, together with the careful avoidance of snags, will do much to improve termite-ridden tea. The great point is to keep hide-bound wood out of the bushes as far as possible. A branch which has become hide-bound will only go backwards, and as this happens the damage done to it by ter-

mites will become greater and greater. One badly infested branch, besides being unprofitable, is a source of danger to all other branches on the bush, and by its removal not only will it be replaced by a new, resistant, profitable shoot, but the remaining branches will also benefit.

To summarize, in the Luskerpore Valley the termites which attack the plucking bushes take two forms, in one of which they build a mound, and do comparatively little damage to the tea, in the other of which there is no mound, and the damage done to the tea is considerable. The mound can be levelled, and will be kept down by continual cultivation, but whether the nest is entirely destroyed by this means, or whether the termites of the colony can take on the habits of the other form, is as yet unknown. In the form which damages the bushes the main nest is situated at a considerable depth below ground, and is therefore untouched by cultivation, which is of benefit only in so far as it keeps down and partly destroys the auxiliary nests near the surface. Owing to the small width of the passages connecting the auxiliary nests with the main nest fumigation, with existing apparatus, would appear to be impracticable. Mitigation of the damage is therefore, so far as we can at present judge, more likely to be effected by preventive measures, based on a knowledge of the nature of the attack on the bushes, and designed to render them more resistant to this attack. In devising such measures we are assisted by our knowledge of the following facts :—

- 1.—The damage almost invariably commences above ground and the insects only work below the collar of the bush in very exceptional circumstances.
- 2.—Hide-bound and moribund wood is more liable to attack than strong healthy productive wood.
- 3.—Young shoots coming from the collar or from healthy and undamaged wood are less liable to attack than those from hide-bound and damaged parts of the bush.
- 4.—Termite attack, while resulting in the ultimate death of the portion of the bush attacked, does not appear to

seriously impair the vitality of the remaining unattacked portions, and, given the opportunity, the bushes will throw out new growth to replace that destroyed by the insects.

- 5.—The presence of a boss of wood above the collar is undesirable, as it affords a place wherein the termites can work undisturbed for a considerable time, and at which they will gradually sap the vitality of the upper portions of the bush connected with it, until portions are brought into a condition suitable for their needs.
- 6.—The attack is commenced by the small workers, the large workers only beginning to go up into the bushes when the small ones have become fairly well established.

Having regard to the above-mentioned facts, the measures recommended are as follows:

- 1.—All young tea, when cut back, should be cut to the ground, and not to twelve inches, in order to avoid the formation of single-stem bushes.
- 2.—Existing single-stem bushes which have become badly attacked should be cut back to the collar, either straightway or after notching.
- 3.—Badly damaged, hide-bound, and unproductive wood should be removed to make way for new productive growth. If there be much bad wood in the bushes, its removal may be carried out gradually, a certain amount being taken away each year.
- 4.—In cases where the bush is throwing out a new shoot below the point of attachment of a badly damaged unproductive branch, that branch should invariably be removed to allow of the new shoot taking its place.
- 5.—Attempts should be made, where termite attack is just commencing, to prevent the insects from becoming

established in the bushes. This can be done, to a certain extent, by good cultivation and kurpying, and thullying round the bushes, but it will not keep the insects away if the pruning be not attended to at the same time.

FUNGUS BLIGHTS OF TEA IN NORTH-EAST INDIA DURING THE SEASON 1915.*

The reports from the Sub-district Chairmen were rather unsatisfactory ; but it is hoped that in the future when the purpose of these report is better understood they will be more useful. The following remarks are for the most part prepared from the notes made by the Mycologist himself. There was no outstanding feature in the fungal attacks in any district, and taken all round, 1915 was not a bad year for blight.

LEAF DISEASES.

BLISTER BLIGHT.

(*Exobasidium versans*).

DARJEELING.—Blister blight was not so prevalent this year as it was in former years. This was probably due to better climatic conditions.

TERAI.—Very little blister was found in this district.

DOOARS.—Blister was present on a few gardens near the hills but it has not been very bad.

ASSAM.—A few gardens only had serious attacks but the disease could be found on abandoned tea in Upper Assam during most seasons of the year. Fortunately the climatic conditions did not favour a serious outbreak but should favourable conditions arise this year there would be nothing to prevent the disease causing serious damage.

CACHAR AND SYLHET.—The disease has not yet been found in these districts.

* See "Insect Pests of Tea in North-East India during the Season 1915." Part I of 1916 Quarterly Journal.

74 FUNGUS BLIGHTS OF TEA IN NORTH-EAST INDIA—SEASON 1915.

COPPER BLIGHT.

(*Laestadia camelliae*.)

This disease was common on broad leaf jats in all districts. No special treatment has so far been carried out for this blight but it is increasing in intensity every year.

GREY BLIGHT.

(*Pestalozzia sp.*)

This disease was to be found on all gardens but it is not nearly so common as Copper blight. The fungus usually attacks the spots caused by other fungi or by insects. It cannot be regarded as a dangerous parasite.

BROWN BLIGHT.

(*Colletotrichum camelliae*.)

Wherever the tea plant is in an unhealthy condition, there Brown blight will be found during the cold weather and early rains. It was not specially prevalent in any particular district. No special treatment has been carried out.

RIM BLIGHT.

(*Cladosporium sp.*)

ASSAM.—Rim blight was very common in Upper Assam but was not so serious during last year as it was in previous years. There is every prospect that its attack will be still less serious in the future as a large portion of the tea in Doom Dooma (the worst affected district) was sprayed with fungicidal mixtures during the cold weather. This disease generally attacks young leaves of the better jats of tea causing the margins to shrivel up. This condition is caused by a fungus which attacks the leaves at the serrations on their edges spreading over the under surface where it produces a greenish coloured down. The disease is being fully investigated and cultures are now growing in the laboratory at Tocklai.

RED RUST.

(*Cephaleurus virescens.*)

Red rust resembles brown blight in that it usually confines its attention to tea which has been weakened by other causes. It was common in all districts.

CACHAR AND SYLHET.—It was specially prevalent in Cachar and Sylhet after the floods. It attacks the leaves and stems after Mosquito blight causing grey spots which resembled those caused by Grey blight. On the stems it caused callosities very similar to those formed by Canker.

STEM DISEASES.

THREAD BLIGHT.

(*Sterile mycelium probably a corticium.*)

ASSAM.—The improvement in the pruning has caused a very great diminution in the attacks of the blight. The caustic washes which many planters use on cut back in the cold weather also tend to further reduction. Thread blight has ceased to be an important disease in most of the districts.

CACHAR AND SYLHET.—Thread blight is very prevalent during the rainy season on most gardens especially on narrow shaded heels between teelas. The application of lime-sulphur solution four times the strength suggested in the spraying pamphlet during the cold weather has been found quite successful even without cutting out the infected wood. The spraying of unpruned tea in Cachar and Sylhet is a very difficult operation but it is the simplest way of dealing with a severe attack of Thread blight on such tea.

Darjeeling, Dooars and Terai had nothing special to report.

VELVET BLIGHT.

This disease has been reported in Darjeeling where it is said to be spreading rapidly. The following treatment has been suggested provisionally. Spray with copper soda emulsion: a few days later rub off the dead fungus and spray again. The Mycologist will visit Darjeeling soon and will then take the opportunity

of investigating the disease on the spot and observing the results of the treatment where it has been applied.

ROOT DISEASES.

(*Hymenochaete noxia.*)

Specimens of this fungus were received from all districts except Darjeeling. It was specially prevalent on sandy soils.

(*Ustulina zonata.*)

Specimens were received from all districts.

(*Rosellinia spp.*)

This disease appear to be associated with water-logging or hard pan in all districts.

CACHAR AND SYLHET.—After the floods many bushes were attacked by a species of *Rosellinia*. Some recovered but many died right out. With the removal of the abnormal conditions the disease ceased to spread.

(*Thyradaria tarda.*)

ASSAM.—This disease, formerly known as *Diplodia* root disease, was found in Dibrughar and the North Bank districts. It is specially prevalent on cleared grassland. This fungus is a common disease of sugarcane and it is probable that the wild sugarcanes which abound on grassland are responsible for its presence on tea planted on such land.

(*Fomes lucidus.*)

The disease was always associated with decaying stumps.

ASSAM.—This fungus was found in Sibsagar and Golaghat.

CACHAR AND SYLHET.—A single specimen was received from this district.

DARJEELING.—Some specimens were received from one garden where about half a dozen bushes had died.

RECENT TOURS.

CHIEF SCIENTIFIC OFFICER.

On the 27th of February the Chief and Second Assistant Scientific Officers proceeded from Jalpaiguri to Margaret's Hope Tea Estate where some soil samples were taken for the soil survey. On the 1st of March they left for Hasimara arriving there on the 2nd. This district is remarkable for the presence of a peculiar white soil, sandy in some places, silty in others, a soil which contains a high percentage of magnesia and which is characterized by having a very soapy feeling to the touch, particularly the more silty types. This soil occurs at Mechpara, Kalchini, Bhatkawa, Dima and in other places in this district in patches. A similar soil is also present in other districts in the Dooars, for example, near the Leesh River, and will necessitate special enquiry in the soil survey. Several gardens in this district were visited and samples of soil taken.

The Chief Scientific Officer left for Calcutta on the 4th of March reaching there on the 5th. He remained in Calcutta until the 14th and attended the Annual General Meeting of the Indian Tea Association, which was held on the 8th, and, as is usual on the occasion, he reviewed the work of the Department for the past year.

On the 15th he left for the Toorsa Jainti district and visited several more gardens and on the 19th left for Dina Toorsa district visiting Banarhat Tea Estate, the soil of which is very different from that of the Dina Toorsa district and has a superficial resemblance at least to the soils of the Golaghat district of Assam. From there he went on the 21st to Baradighi being much interested in the work which is done there to prevent the loss by wash of the very light soil of the garden from slopes.

On the 22nd he left for Jalpaiguri to deal with office work and proceeded on the 24th to Darjeeling where he gave a lecture

on the 25th to members of the Darjeeling Planters' Association on soils. He left Darjeeling on the 28th and reached Calcutta on the 29th.

On the 5th of April the Chief Scientific Officer left Calcutta for Sylhet. He arrived at Rasidpore on the 8th and there witnessed one of the most severe hail storms which has been experienced in this district. The hail stones were not large in comparison with those which are frequently seen in remarkable hail storms. They were perhaps from an inch to an inch and a half in diameter, but a feature of this storm was the strong driving wind which came with it. Parts of several gardens in this district were entirely defoliated and the damage done to the bark of the bushes was extremely serious. About three weeks later when he again saw one of these gardens very little recovery had taken place. The Chief Scientific Officer arrived in Silchar on the 11th and left next morning for Siluri where it had been intended that he should meet a number of planters in the district. Unfortunately only a few were able to attend owing to the weather being very bad. On the following day he went round this Company's estate and was shown a piece of deteriorated bheel from which several bushes have since been dug up which have been found to contain shot hole borer, *Xyleborus fornicatus*. This pest is better known in the Ceylon tea districts than in those of North-East India and it is a very serious pest there. For this reason the Entomologist is keeping a close watch on the occurrence and distribution and possible spread of this pest in North-East India so that in the event of its being found that it is spreading rapidly precautionary measures may at once be adopted. In Ceylon the occurrence and life-history and possible means of combating this pest are being carefully worked out. On the 13th the Chief Scientific Officer went to Rosekandy and from there on the following day to Ruttonpore arriving that evening at Bora Jalinga. Rosekandy and Ruttonpore are the examples of estates consisting chiefly of "kunchis" that is long narrow strips of level land running in among tilas. The soil in such "kunchis" in Cachar often consists of real bheel, but in the case of these two gardens it is a reddish loam, clayey in places and sandy in others, and sandy in all cases



Fig. 6.

Photograph of a branch of a tea bush showing serious hail damage.

near the tilas, which in this district appear to be of a sandy rather than a clayey character. It is hoped that more information may be forthcoming shortly with regard to the composition of these soils for they appear to be of a type peculiar to themselves. A curious and at present unexplained feature of cuttings through tilas in this district is the remarkably bright pink colour in places of the sandy rock of the tilas.

On the evening of the 14th the Chief Scientific Officer arrived at Bora Jalinga and on the next day went round that garden and on the following day went to Allenpore and Derby returning to Bora Jalinga that evening. While at Bora Jalinga he collected samples of bheel soil to send to the Imperial Economic Bacteriologist at Pusa who is investigating toxins in Indian soils. On the 17th he left the Chutla Bheel district for Kalacherra and saw part of that garden before going on to Lallamukh. Parts of Kakacherra had also been badly affected by hail. That afternoon he went round Lallamukh and the following morning proceeded to Lallachera and from there to Rupacherra for tiffin where an informal meeting was held attended by seven planters. He left that evening for Kokicherra and on the following morning, the 19th, after seeing that garden saw part of Manipur Garden on his way to Doloi. In Manipur Garden there is a remarkably fine piece of tea on a well-drained flat, the soil of which cannot be said to have the appearance or feel of a first class tea soil. This soil merits particular enquiry particularly as the neighbouring gardens, Kokicherra and Doloi, have clearances on soils which appear to approximate to some extent to this type. On the 20th after seeing part of Dokoi he rode through Appin to Koyah arriving there in time for tiffin, and saw round that garden in the afternoon going to Ainakhall that evening. Koyah is a good example of a fine bheel garden. On the morning of the next day, the 21st, he saw part of Ainakhall garden and in the afternoon was motored to Salchapara and from there he returned to Silchar. On the 24th he went to Dooloo returning to Silchar on the morning of the 27th and left Silchar that afternoon for Boraoraa arriving late at night. He saw part of this garden the next morning and met several neighbouring planters and was driven that evening to

Phulcherra. On the following evening he went to the Kalighat Club where he addressed a meeting of about 20 planters. After staying at Deanston and seeing part of that garden the next day he went on *via* Rajghat to Amrailcherra. A great deal of excellent work is being done on these gardens. They are drained well and excellent bunding work is being done on slopes, the bunds however have not got contour drains on the lower sides. It would be of advantage if these were made. Study of the latest information of this Department on the growing of green crops and of shade trees would repay those who are engaged in improving estates by this means in this district. There appears to be a tendency to work on stereotyped lines without sufficient consideration being given to individual conditions. It is noticeable that pruning is obviously the limiting factor in crop production in this district, that is to say pruning is not carried out as well as other operations are, and better pruning alone—not more drastic pruning but more correct pruning—would increase the yield from these gardens considerably. This is merely a restatement of what has been said by the Department many times in regard to pruning in the Surma Valley as a whole. In the Balisera Valley the possibilities of improvement appear to be great and it is felt by the Scientific Department that more detailed attention to the scientific aspects of tea culture and their careful and liberal application would result in far better results than are obtained at present, satisfactory as these may appear to be. On the 31st the Chief Scientific Officer saw round Amrailcherra and went to Sathgaon that evening. On the morning of the 2nd of May he saw a remarkably promising piece of young tea. The growth of the young plants cut down to within 2" of the ground was remarkable. A very large number of thick young shoots were breaking away from the collar. A specimen of this was photographed with a view to illustrating the excellent results which can be obtained by correct procedure. On the afternoon of the 3rd he went to Rasidpore and on the following day after seeing part of that garden he went to Teliapara where some interesting and well designed bunding operations were in progress. On Teliapara and Surma gardens bushes are high and narrow. It is a ^{too}

common axiom that bushes of this type, which usually owe their undesirable shape to faulty pruning years ago, can only be economically renovated by collar pruning. The Chief Scientific Officer took the opportunity of demonstrating methods which if applied consistently will produce the desired development of a low spreading bush in the course of a few years and with less loss of crop during the same period than would be occasioned by collar pruning. The next day he went to Chandicherra and in the evening to Amo. The next day he saw Amo and returned to Chandicherra in the evening and on the next morning, the 9th, after seeing parts of Chandicherra and of Chandpur he returned to Teliapara and left that night for Calcutta arriving on the 10th.

ENTOMOLOGIST.

The Entomologist spent the greater part of the month of April in advisory touring in the Dibrugarh and Doom Dooma districts, visiting the Borbooroah, Romai, Beheating, Maijan, Greenwood, Ethelwold, Barbari, Rajghur, Nagagholie, Balijan, Sealkotee, Panitola, Kanjikoah and Woodbine estates of the former district, and the Budla-Beta, Bokpara, Diamukia, and Dhoedam estates of the latter district.

An address on "Garden Operations and their influence on insect attack" was given at the Doom Dooma Club on the 26th of the month, at which twenty-five were present.

There is a noticeable freedom from serious insect attack in these districts, and this is the more remarkable when one takes into account the fact that most of the insect pests of tea were noticed in these districts during the visit. The more serious pests at this time of the year are red spider (*Tetranychus bioculatus*) the tea aphid (*Bucktonia theaecola*) the tea tortrix (*Homona coffearia*) and faggot and bag worms (*Clania crameri* and *C. variegata*). Other pests of tea observed were Peals' beetle (*Diapromorpha melanopus*), tea mosquito (*Uelopeltis theivora*), termites. The leaf-perforating psychid (*Acanthopsyche snelleni*), the Badamtam bark-eating borer, cocoons of gelatine and nettle grubs (genera *Belippa* and *Thosea*), scarlet mite (*Brevipalpus obovatus*), red slug (*Heterusia magnifica*), looper (*Biston suppressaria*), crickets

(*Brachytrypes achatinus*), the white tea-leaf louse (*Chionaspis theae*), the brown bug (*Lecanium hemisphaericum*), *Psocus taprobanes*, *Syntomis atkinsonii*, the caterpillar of the tea tussock moth (*Aenea mendosa*), green fly (*Empoasca flavesrens*), *Tettigoniella leopardina*, and the cluster caterpillar (*Andracia bipunctata*).

MYCOLOGIST.

In accordance with the programme the Mycologist visited Dibrughar and Doom Dooma during April. His particular object in visiting these districts was to obtain information concerning the spraying machines in use there and discuss ways of improving them. His original intention was to arrange a demonstration in each district at which a number of each of the commonest types of machine would be shown working in competition. This fell through owing to the state of repair of the available machinery. This was for the most part due to the impossibility of replacing worn out parts. It was possible however to carry out one experiment. There are two distinct types of machines in use—the knapsack type and that in which the pump is attached to a tank or barrel, the spraying fluid being conveyed to the nozzles along one or more flexible tubes. It was first of all necessary to determine whether either of these showed a marked superiority over the other. Improvements of the more satisfactory type could then be considered. A "standard" machine provided with two long rubber pipes with Vermoral nozzles attached and mounted on legs so that it could be carried about easily was tested against the pneumatic knapsack sprayers with internal pumps. The tea to be sprayed was marked out with bamboos and the solution placed in convenient positions so that there would be no delay in filling the machines. In the case of the standard machines the tea area was marked out into squares. The squares were just the right size for the machine to spray without being moved. Four coolies were found necessary for the standard machine—One to pump, two to direct the spray and another to carry the fluid. Three coolies were found to be sufficient for the two knapsack sprayers. The two knapsack machines did double the number of bushes the standard machine could do. This appears to be sufficient proof that the knapsack type is preferable to the stationary type.

Suggested improvements in Spraying Machinery.

To one without experience of tea garden labour it would seem that machines of the pressure type whether with internal or external pumps would be simple and durable enough for garden use, but it has been shown that even these machines are unable to withstand the ill-treatment they receive. It is not an exaggeration to say that there is not a single machine in any of the districts visited which could be declared sound after three months work. Machines of the continuous pumping variety get out of order in a much shorter time. The many attempts that have been made to improve the cooly have ended in failure and the only possible way of making spraying a practical operation is to still further simplify the machinery which is to be placed in his hands. It is therefore put forward as a suggestion that if the knapsack portion of the apparatus, *i.e.*, the portion which is under the direct control of the cooly—were merely an air-tight cylinder of non-corrosive metal provided with a simple non-leaking tap (the whole apparatus including the tap to be tested to stand a pressure of say 90 lbs. per square inch.) less trouble might be occasioned by mishandling. A number of these machines say 20 or 30 could be worked in conjunction with a single portable charging pump which would be provided with all the necessary valves and gauges. This pump would have large wearing surfaces in consequence of its size and thus would be less likely to get out of order. Further it might in this case be possible to place a competent mistri in charge of it. The Mycologist has noticed that in the case of all pumps to be used by coolies it is better to have a wheel and eccentric rather than a lever or direct motion, the reason being that in the latter cases the cooly rarely makes a full stroke. This means waste of labour and is also bad for the machine.

The Nozzle.

The most important item in a spraying outfit is the nozzle for unless the nozzle be suitable, no matter how efficient the rest of the machine may be, the work will not be satisfactory. Caustic washes are very hard on nozzles. The apertures are very frequently so much enlarged that the spray produced is much too coarse

to be any use at all. In most nozzles the aperture is situated in a detachable metal disc and it is a simple matter to replace these discs whenever necessary. If these discs were of glass instead of metal it would probably be an improvement, as the aperture would be less liable to wear by friction and corrosion and in consequence the spray would be more constant. Some of the nozzles produce their spray some distance from the nozzle. The coolies hold the nozzle so close to the bush that the spray is never produced, the jet pouring down the branches nearest to it in an unbroken stream. From observations made in the various districts the Mycologist is of the opinion that half the spray fluid applied last year was wasted owing to unsuitable or badly kept nozzles.

A nozzle for use in spraying tea is very easy to choose. There is no need to have it adjustable as the tea bushes do not vary much in size. There is no need to have an elaborate non-clog arrangement as this is more likely to go wrong than the nozzle is to clog. All planters, who do any spraying on a large scale, strain their fluid carefully so that the nozzle is not likely to clog.

The following points must be noticed :—

1. The aperture must be replacable.
2. The spray must be produced as close to the aperture as possible.
3. The whole arrangements must be very simple with no leaky joints requiring washers, etc.
4. The spray produced must be as fine as possible but in sufficient quantity to cover the bush in a short time.

The arrangement of the Nozzle.

The most usual method of connecting the nozzle to the machine is by means of a short length of brass piping, to serve as a handle, and a flexible tube which connects this brass tube to the container. This nozzle is attached to the handle at an angle so that the application of the spray fluid to the undersides of the leaves is facilitated. With this arrangement the operator is able, by directing the jet intelligently, to spray the bushes thoroughly. Unless the supervision be very good the jet is not directed intelli-

gently. An arrangement is required to render the operation of applying the spray fluid more automatic so that the easiest way—the way the cooly naturally goes—will be the correct way. An attachment provided with sufficient nozzles might for instance be arranged in such a manner as to enable the halves of the bushes on each side of a gully to be sprayed automatically as the operator walks straight down it.

Rim Blight.

When there was nothing more to be done with spraying the Mycologist took the opportunity of investigating rim blight. This has been causing serious damage to tea in Northern Assam, but it has not been possible to investigate it until this year. The blight is caused by a fungus which appears to attack the young leaves at the serrations on their edges. From these it spreads inwards causing a brown patch which appears to be much thinner than the healthy portion of the leaf. The brown stage is generally preceded by the diseased portion of the leaf turning pale yellow. Some days after the brown stage has been reached tufts of dark green hairs develop on either or both sides of the leaf. These are spore-bearing. A later stage than this has not yet been found on the leaf. The fungus spends the most important stages of its life on the epidermis hence spraying with a fungicidal solution such as Bordeaux mixture would be beneficial. It is noticeable that the worst rim blight was seen on severely pruned tea and it is quite possible that the pruning helped to render the plant more susceptible to the attacks of the fungus. It was pointed out that portions of the garden sprayed with caustic washes during the cold weather had less of this blight than untreated ones.

The effect of caustic winter washes.

Many of the planters in these districts have been spraying their tea with caustic winter washes.

Plain caustic soda solution has been used extensively and those who have applied it seem to be very pleased with the results. To get the best results, the solution should be applied early in the cold weather otherwise the tea is set back a little. Planters

say that this set-back is only temporary, the tea coming away better than the untreated. In some cases probably the application of caustic soda has been made unnecessarily. It is intended to remove the causes of a hidebound condition and it is not likely to help really healthy vigorous plants. Bordeaux mixture applied in March or April would help the latter much more.

The Mycologist returned to Tocklai on May 4th.

The Entomologist met the Mycologist at Budla Beta and conferred about the spraying. The Entomologist found a jungle leaf with a blister which, to the naked eye, resembled blister blight to a very remarkable degree. As this leaf was found underneath a blister blighted tea bush additional colour was lent to the theory that the blister on the jungle was true blister blight. Microscopic examination showed, however, that the blister was caused by a species of *Puccinia* and was not allied in any way to *Exobasidium vexans*, the fungus causing blister blight of tea.

NOTES.

Insect pests of tea Dadap and Albizzia.—In the Sixty-Second Annual Report of the Planters' Association of Ceylon, the following insects are mentioned as having been found on tea, dadap, or *Albizzia* during 1915 :—

ON TEA.

- “Red Borer” (*Zenzeria coffeae*)—serious in several districts.
- “Red Slug caterpillar” (*Heterusia cingala*)—serious in a few districts, the attacks characterised by the extreme suddenness of their appearance.
- “Cockchafer grub” (Larvae of various Lamellicorn beetles)—reported from several districts as serious in nurseries.
- “Nettle grubs” (*Natada nararia* and others)—serious in a few districts in the autumn: the attack, like that of the Red Slug, appearing with great suddenness and spreading with great rapidity.
- “Tea Tortrix” (*Homona coffearia*)—very severe in several districts.

The following tea pests occurred, but were not serious :—

- “Tea-mosquito” (*Helopeltis antonii*.)
- “Purple-mite” (*Phytoptus carinatus*.)
- “Small Tussock Caterpillar” (*Orgyia postica*?)
- “Lobster Caterpillar” (*Stauropus alternus*.)
- “Bag worms, Faggot worms” (various species of the family *Psychidae*.)

ON DADAP.

- “Large Yellow Tussock Caterpillar” (*Dasychira horsfieldi*.)
- “The Dadap Shoot Borer” (*Terastia meticulosais*.)
- “Paddle-legged Bug” (*Anoploinemis phasiana*.)

ON ALBIZZIA

"Bark-eating Borer" (*Arbela quadrinotata*.)

"Black and yellow butterfly" (*Terias silhetana*)—also reported as defoliating *Sesbania grandiflora*.

ON SENDING SPECIMENS ATTACKED BY FUNGUS DISEASE.

Fungi of the kind commonly parasitic on tea are not so difficult to pack as insects. To begin with it is not always necessary for them to be alive when they reach this office. Some of them survive conditions which would kill most organisms. Effort should be made, however, to pack them in such a way as to ensure their reaching the laboratory in the same condition as they left the garden, so that the Mycologist may see the effects of the disease more or less as he would see it if he visited the garden.

In sending specimens the following points should be observed :

1. The specimens should be representative of the general effect of the blight. If they are of different stages or peculiar forms, they should be labelled as such.
2. Send a sufficiently large quantity for the Mycologist to gain some idea of the progress of the disease for himself.
3. Send as full information as possible on the following points :—
 - a. The nature of the soil.
 - b. Any recent alteration in the treatment of the soil which may have some bearing on the case.
 - c. The history of the attack.

The mycological staff must be excused if they are unable to reconstruct the whole history of the blight from a single scrap of evidence. The necessity of waiting for further information means delay, and in most cases of severe attacks of blight a delay is fatal.

In packing specimens of fungus blights special care should be taken to avoid excessive moisture. A point of special importance in the case of root disease specimens is to avoid loose fragments which are likely to shake about.

From our experience of the last five years the following packing recommends itself.—

Leaves and green shoots may be packed between blotting paper or failing that two or three thickness of newspaper. There is no need to send them flat: they may be rolled up. Roots and dry stems may be sent wrapped up in gunny cloth as they travel better this way than when in a box.

Needless to say the name of the sender should not be forgotten. It should be written both on labels attached to the specimens and on the cover of the package.

ON SENDING SPECIMENS OF PLANTS FOR IDENTIFICATION.

The classification of plants is based principally on the morphology of the flowers and fruits. The vegetative portions are frequently useless for purposes of identification unless they be distinguished by some marked peculiarity.

A specimen for identification is examined at Tocklai and is generally identified by reference to books. The book identification is then verified by comparison with specimens in the herbarium. Of course, in the case of the commonest plants, it is frequently possible to identify them without referring to any books, simply by comparison with others in the collection. At the present time our library and our herbarium are very small and it is frequently necessary to send specimens to Calcutta—the Indian Museum or the Botanical Gardens.

We prefer to receive unmounted specimens. They should be despatched rolled up between blotting paper or newspaper. The specimens need not be dried; but they should never be wet. Labels should be attached to the specimens themselves not only to the wrappers as the specimens frequently become separated from their packing. Details of the general habit of the plant, kind of place in which it is most commonly found, the native name (if any) are all valuable, and should be given where possible. Specimens will only be returned by special request.
